

System-Level Planning, Coordination, and Communication

Care of the Critically Ill and Injured During Pandemics and Disasters: CHEST Consensus Statement

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BACKGROUND: System-level planning involves uniting hospitals and health systems, local/regional government agencies, emergency medical services, and other health-care entities involved in coordinating and enabling care in a major disaster. We reviewed the literature and sought expert opinions concerning system-level planning and engagement for mass critical care due to disasters or pandemics and offer suggestions for system-planning, coordination, communication, and response. The suggestions in this chapter are important for all of those involved in a pandemic or disaster with multiple critically ill or injured patients, including front-line clinicians, hospital administrators, and public health or government officials.

METHODS: The American College of Chest Physicians (CHEST) consensus statement development process was followed in developing suggestions. Task Force members met in person to develop nine key questions believed to be most relevant for system-planning, coordination, and communication. A systematic literature review was then performed for relevant articles and documents, reports, and other publications reported since 1993. No studies of sufficient quality were identified upon which to make evidence-based recommendations. Therefore, the panel developed expert opinion-based suggestions using a modified Delphi process.

RESULTS: Suggestions were developed and grouped according to the following thematic elements: (1) national government support of health-care coalitions/regional health authorities (HC/RHAs), (2) teamwork within HC/RHAs, (3) system-level communication, (4) system-level surge capacity and capability, (5) pediatric patients and special populations, (6) HC/RHAs and networks, (7) models of advanced regional care systems, and (8) the use of simulation for preparedness and planning.

CONCLUSIONS: System-level planning is essential to provide care for large numbers of critically ill patients because of disaster or pandemic. It also entails a departure from the routine, independent system and involves all levels from health-care institutions to regional health authorities. National government support is critical, as are robust communication systems and advanced planning supported by realistic exercises.

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ABBREVIATIONS: HC/RHA = health-care coalition/regional health authority

Summary of Suggestions

National Government Support of Health-care Coalitions/Regional Health Authorities—Policy

1a. We suggest political leadership at national levels should support health-care preparedness through financial assistance, support of market driven incentives, and preparedness requirements to health-care coalitions/regional health authorities (HC/RHAs).

1b. We suggest national governments should support the development of responsive and nimble disaster/pandemic research processes that can both organize and assess information from prior disasters/pandemics, acquire real-time data in an ongoing one to provide situational awareness, and which can also learn from and support international disaster relief efforts.

1c. We suggest national, state/province/regional, and city/district governments should:

- **Working with health-care experts and leadership, develop formal legal disaster/pandemic activation mechanisms to initiate, implement, and support disaster/pandemic plans and standards of care for HC/RHAs and healthcare professionals; and legally initiate step down termination procedures and processes as conditions and criteria warrant in the recovery phase**
- **Work with health-care experts and leadership in the greater health-care community to develop and refine specific “trigger” criteria for formal legal activation and step down termination procedures and pro-**

cesses of disaster/pandemic plans and standards of care.

1d. We suggest local governments and government agencies should be formal partners in their local health-care coalition(s), and be actively engaged with their ongoing preparedness and response activities.

Teamwork Within HC/RHAs—Foundational Principles

2. We suggest health-care coalition partners should work together, with the following objectives:

2a. HC/RHA clinical and administrative leaders from all partners meet together on a routine, scheduled basis. Clinician leaders must include critical care medicine experts.

2b. HC/RHA clinical and administrative leaders from all partners work together at least yearly with primary focus on developing and updating joint disaster/pandemic preparedness plans based on likely events (Hazard Vulnerability Analyses).

2c. HC/RHA clinical and administrative leaders from all partners jointly practice activation and implementation of disaster/pandemic plans and standards of care through exercises.

2d. HC/RHA partners activate their communication and collaboration mechanisms for virtually all actual or potential surge events, or unusual or large scale planned or unplanned events requiring cooperation, to ensure optimal responses and enable experience working together.

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2e. HC/RHAs identify clinical experts to oversee and address the needs of specific populations, especially pediatrics, and also specialty populations such as trauma, burns, oncologic, etc.

2f. HC/RHA clinical and administrative leadership should be defined by position, not specific personnel, consistent with Incident Command System (ICS) nomenclature or equivalent, and designed with appropriate redundancy.

System-Level Communication—Foundational Principles

3a. We suggest HC/RHAs should have secure online and/or published directories for all partners' clinical and administrative leadership, with emergency contact information (phone numbers, e-mail addresses, pagers, cell phone texting preferences, other means) and current call schedules.

3b. We suggest HC/RHA's should have defined communication vehicles which may include (but are not limited to): dedicated secure health-care coalition web sites; conference call lines and teleconferencing technologies (eg, Skype, others); hospital phones (land lines and cell phones); pagers, hand-held walkie-talkies, ham radios, or other similar means of communication; telemedicine technologies, such as E-ICU, integrated into their disaster plans.

3c. We suggest HC/RHA partners should attempt to routinely use those agreed upon communication vehicles when working together.

3d. We suggest all agreed upon communication vehicles should be tested on a scheduled basis, with objective criteria to validate the test.

3e. We suggest the choice of communication vehicles and testing may be based on likely disaster/pandemic events (Hazard Vulnerability Analyses), and/or other appropriate considerations.

3f. We suggest developing defined disaster/pandemic plans for monitoring and leveraging popular social media (eg, Twitter, Facebook, others) during all actual or potential surge events, or unusual or large scale planned or unplanned events requiring cooperation, as both a means for gathering and transmitting information, as appropriate.

3g. We suggest HC/RHAs should have defined communication tools designated for each level of

organizational leadership, which should be consistent with ICS structure or equivalent.

System-Level Surge Capacity and Capability

4a. We suggest HC/RHA surge objectives should be consistent with individual hospital surge goals and include the capability to surge to:

- Up to 200% above routine maximal capacity based on the nature and severity of the disaster (contingency to crisis)
- Up to the limit of the total number of ventilators available to coalition partners.
- Up to projected patient loads in a slow onset, slow evolving disaster.

4b. We suggest HC/RHAs should be able to monitor and track their defined surge capacity supplies and equipment, ideally "real time" and electronically, with the intent of being able to use all HC/RHA assets. These supplies and equipment may include identified caches of important medications or equipment, and bed availability among partners.

4c. We suggest HC/RHAs should have the ability to track the number of available ICU capable personnel ("force multipliers") and other designated specialist "resources" (eg, pediatric and special populations) through their partner hospitals. Partners with telemedicine capability (such as tele-ICU's) should have plans for how to use this resource to optimize the use of pediatric and specialty expertise across hospitals served by the telemedicine resource.

4d. We suggest HC/RHAs should have defined policies and procedures for emergency privileging for all health-care professionals designated as coalition resources.

4e. We suggest fair and adequate reimbursement for expenditures and loss of revenue related to delivery of acute critical care services during a disaster or pandemic must be ensured. This should include the guarantee of payments from governmental sources, as well as by insurance companies and other payers of health-care services.

Pediatric Patients and Specialty Populations

5a. We suggest HC/RHAs have identified, and be familiar with, the following pediatric disaster/pandemic designated resources including, but not limited to:

- Pediatric consultative specialists available by dedicated phone line support and/or dedicated video or telemedicine consultation.
- Designated pediatric surge personnel (eg, pediatric hospitalists, others) available to non-pediatric hospitals and health systems to support surge in contingency or crisis level events, with a defined plan for how to activate this resource when needed.
- Identified pediatric capable transport resources for allocation and matching of pediatric patients to available HC/RHA pediatric resources.
- Knowledge of available key supplies, medications, and other pediatric assets; location of these assets with a defined process for how they may be accessed urgently; and ability to monitor when asset reserves fall below a defined critical threshold.
- Pediatric educational resources. If web-based, they should be found on HC/RHA websites, or with links to appropriate resources. If published, resources should be readily available to all partners.

5b. We suggest HC/RHAs should have plans to provide care for specialty populations routinely found in their catchment area or region in parallel as described for pediatrics. Resources should include consultative services, potential surge personnel, transport resources, specialty supplies/medications, and educational resources. These populations include but are not limited to trauma, nephrology, burns, oncologic patients.

5c. Health-care coalitions, health systems, and hospitals identify patients with high-level chronic disease care needs, such as a home ventilator, home oxygen, chronic dialysis, and work to ensure their needs are met at home to help prevent these patients from having to seek assistance at hospitals.

HC/RHAs and Networks

6a. We suggest during a disaster requiring transfer of patients, whether from emergency medicine departments or inpatient areas, transferring partners may have initial choice of where patients are referred based on traditional referral patterns. However, HC/RHA leadership must oversee this process, and be able to intercede as both a resource and with the authority to redirect transfers based on anticipated or actual events. Defined health-care coalition coordination processes and transfer resources should be planned and identified ahead of time.

6b. Health-care coalitions should designate neighboring health-care coalitions as potential partners

during a contingency or crisis event, and have readily available leadership contact information, and knowledge of these potential partners' size and capabilities.

Models of Advanced Regional Care Systems

7. Advanced Regional Care Systems instituted within large hospitals, and across hospitals, health systems and HC/RHAs, will have the greatest chance for success if they are established with the following goals:

- Clear and transparent objectives for what those programs are to accomplish, and the programs are well integrated and accepted across their hospital and health system partners.
- Have administrative and financial resources sufficient to support the objectives desired
- Are evaluated based on objective outcome measures and best-practice process indicators, and strive for consistent data definitions and goals, which facilitate outcome comparison with other systems.
- Are driven by an impassioned performance improvement culture.
- Have effective communication systems and processes across their hospitals, health systems, and health-care coalitions/regional health authority partners, between potential pre- and post-hospital partners, and with patients and families.
- Develop clear expectations and supportive clinical and educational resources for patients and their families, especially those patients with chronic medical illnesses.

The Use of Simulation for Preparedness and Planning

8. We suggest hospitals, health systems, and HC/RHAs promote the use of computer modeling to gain insight into their operational capabilities and limitations, in the following ways:

- Support the creation of computer models utilizing industry templates in collaboration with their own administrative, clinical, and technical resource experts from participating system partners. Models should include government and military resources when applicable, and include provision of maintenance of chronically ill patient populations.
- Collaborate with modelers in the design, implementation, and testing of these models; and with the interpretation and application of these results.
- Support the data requirements for such system models, and develop repositories for operationally

relevant data that can be used in future modeling efforts.

- **Leverage their relationships with national, regional, and local governments and public health agencies and emergency medical service providers to obtain necessary data on the transportation and patient logistic components of such models as required.**

Introduction

System-level planning is focused on health-care delivery that unites all local health-care organizations, including hospitals, health systems, local/regional government agencies, emergency medical services, and virtually all other health-care entities that may be called on to deliver care in a major disaster or pandemic. In the United States, this is identified as a health-care coalition (sometimes referred to as a tier 2 or Multi-agency Coordination System)¹⁻³ and internationally referenced in this publication as a regional health authority (RHA).

Although community-based health-care coalition/RHAs (HC/RHAs) may not have specific operational authority and thus not be considered a response organization, in collaboration with emergency management and other government partners, an HC/RHA can cooperatively support medical surge planning and response through information sharing and resource coordination.^{1,2,4,5} Specific hospital accreditation requirements may also

define a hospital's role in a community-based emergency medical system.⁶

HC/RHA partners may not routinely work together and may even be competitors but usually will cooperate during a disaster/pandemic. The power of their effectiveness relies on teamwork. Thus, the task force chose to address system-level planning with the intent to develop suggestions to facilitate teamwork among HC/RHAs in conjunction with their government partners to highlight the necessary infrastructure to provide effective mass critical care.

Government support, teamwork, and system-level communication are basic infrastructure for HC/RHAs, and because of their importance, elements of these three principles are briefly reviewed early in this document. Effective teamwork is the foundation for increasing HC/RHA success in all endeavors. Finally, we offer suggestions developed from examples of currently effective advanced regional care systems and simulation models such that these may offer insight to base future system-level design.

The suggestions in this chapter are important for all of those involved in a disaster or pandemic with multiple critically ill patients, including front-line clinicians, hospital administrators, and public health or government officials. Although it is important for all providers to be familiar with the system requirements of disaster and pandemic response, Table 1 provides an overview of the suggestions most of interest to each of the above groups.

Materials and Methods

The Systems Planning panel followed the American College of Chest Physicians (CHEST) Guidelines Oversight Committee's methodology to develop suggestions, based on a consensus development process (see "Methodology" article by Ornelas et al⁷ in this consensus statement). The Systems Planning panel developed nine key questions (see e-Appendix 1 for key questions list and corresponding search terms and

results). A systematic literature review was then performed for relevant articles and documents, reports, and other publications reported since 1993 to 2012; English-language papers were included, and non-English-language papers were excluded. No studies of sufficient quality were identified upon which to make evidence-based recommendations. Therefore, the panel developed expert-opinion-based suggestions utilizing a modified Delphi process.

Results

National Government Support of HC/RHAs—Policy

1a. We suggest political leadership at national levels should support health-care preparedness through financial assistance, support of market driven incentives, and preparedness requirements to HC/RHAs.

1b. We suggest national governments should support the development of responsive and nimble disaster/pandemic research processes that can both organize and assess information from prior disasters/pandemics, acquire real-time data in an ongoing

one to provide situational awareness, and which can also learn from and support international disaster relief efforts.

1c. We suggest national, state/province/regional, and city/district governments should:

- **Working with health-care experts and leadership, develop formal legal disaster/pandemic activation mechanisms to initiate, implement, and support disaster/pandemic plans and standards of care for health-care coalitions/regional health authorities and health-care professionals; and legally initiate**

TABLE 1] List of Suggestions, With Recommended Category of Health-care Professionals for Which Each Set of Suggestions Is Intended

Suggestion No.	Primary Target Audience		
	Clinicians	Hospital Administrators	Public Health and Government
1			✓
2	✓	✓	
3	✓	✓	
4	✓	✓	
5	✓	✓	
6	✓	✓	
7	✓	✓	✓
8	✓	✓	✓

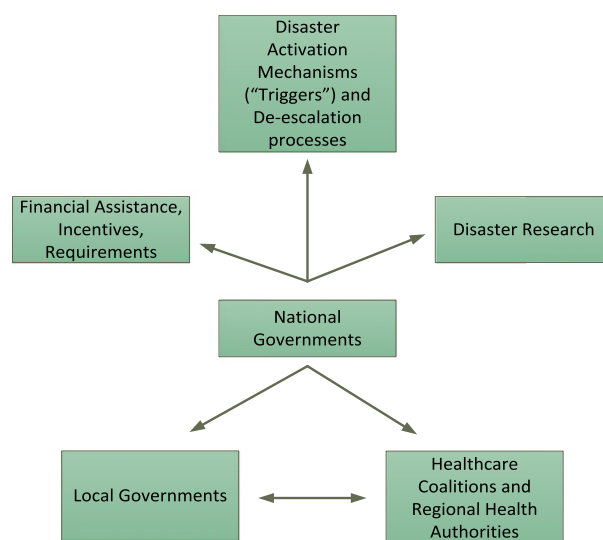
step down termination procedures and processes as conditions and criteria warrant in the recovery phase

- **Work with health-care experts and leadership in the greater health-care community to develop and refine specific “trigger” criteria for formal legal activation and step down termination procedures and processes of disaster/pandemic plans and standards of care.**

1d. We suggest local governments and government agencies should be formal partners in their local health-care coalition(s), and be actively engaged with their ongoing preparedness and response activities.

Since 2002, health-care coalitions in the United States have developed because of financial support and leadership from the federal government.^{4,8} Success in disaster preparedness relies on this level of leadership and coordination. National governments should financially support HC/RHAs with market-led incentives when appropriate and guide establishment of national standards for preparedness and response (Fig 1).

Active government participation in health-care coalitions in the United States ensures integration with local public health authorities, emergency medical services, and health-care providers such as nursing and mental health facilities, which have previously been omitted from the emergency preparedness community.^{4,8} Government-health care partnerships are an important component of both preparedness and successful response capabilities.⁹ These partnerships are important because HC/RHAs are vulnerable to disruptions of normal patient care during virtually any disaster, leading to potential mismatch of need and resources.^{5,10} Although dedicated resources for developing triggers



GOVERNMENT

Figure 1 – National governments and suggestions for support of disaster preparedness (top three boxes) and suggestions for continuing to work with local governments and health-care coalition/regional health authorities to facilitate preparedness planning (bottom two boxes).

for implementing and terminating crisis standards of care are available, the work of developing them is a responsibility of local health-care and government leadership.^{11,12} Government leadership, in collaboration with health-care experts, is needed to define specific criteria for activation of emergency response plans, including when “crisis standards of care” are invoked and when they are terminated, and provide guidance for providers and health-care systems¹⁰ (see “Legal Preparedness” article by Courtney et al¹³ in this consensus statement).

There is little scientific evidence to guide disaster preparation and practice. During the 2009 influenza A(H1N1) pandemic, insufficient research infrastructure to initiate clinical studies meant vital questions remained unanswered. Similar gaps have been noted in other disasters, indicating the importance of public health emergency response research.¹⁴⁻¹⁶ We suggest national governments support the creation of a clinical research infrastructure, including predeveloped protocols, data collection instruments, ethical oversight, and funding to conduct necessary research during acute public health emergencies.¹⁶

Teamwork Within HC/RHAs—Foundational Principles

2. We suggest health-care coalition partners should work together, with the following objectives:

2a. HC/RHA clinical and administrative leaders from all partners meet together on a routine, scheduled basis. Clinician leaders must include critical care medicine experts.

2b. HC/RHA clinical and administrative leaders from all partners work together at least yearly with primary focus on developing and updating joint disaster/pandemic preparedness plans based on likely events (Hazard Vulnerability Analyses).

2c. HC/RHA clinical and administrative leaders from all partners jointly practice activation and implementation of disaster/pandemic plans and standards of care through exercises.

2d. HC/RHA partners activate their communication and collaboration mechanisms for virtually all actual or potential surge events, or unusual or large scale planned or unplanned events requiring cooperation, to ensure optimal responses and enable experience working together.

2e. HC/RHAs identify clinical experts to oversee and address the needs of specific populations, especially pediatrics, and also specialty populations such as trauma, burns, oncologic, etc.

2f. HC/RHA clinical and administrative leadership should be defined by position, not specific personnel, consistent with Incident Command System (ICS) nomenclature or equivalent, and designed with appropriate redundancy.

Effective teamwork among all partners is critical for optimal performance of the HC/RHAs in preparedness and response activities.^{1,4,5,8} As evidenced during Hurricane Sandy,¹⁶ the foundation of any team is personal relationships and the development of trust through common work toward mutual goals.¹⁷ Although smaller in scale, trauma networks and telemedicine systems are associated with improved outcomes through regional coordination, with consensus recommendations supporting similar systems for acute coronary syndromes and stroke.¹⁷⁻²⁰ Administrative and clinical leaders meeting, working, and performing disaster exercises together on a routine, scheduled basis serve to create effective teams through professional and social interactions. Meeting annually is believed to be the minimum required to develop effective relationships.

Intensivist expertise in planning and response is also important in pandemics and disasters.^{21,22} Therefore, a critical care physician's expertise should be part of a HC/RHA's leadership planning and operational

structure to aid in patient triage and transfer; help prevent undertriage and overtriage; help coordinate resources and information; serve forward medical response teams (through the National Disaster Medical System or equivalent organizations); and provide a level of portable critical care that can assist local providers and coalitions with inpatient triage, treatment, and transport^{5,21} (see "Surge Capacity Principles" article by Hick et al,²³ "Surge Capacity Logistics" article by Einav et al,²⁴ and "Evacuation of the ICU" article by King et al²⁵ in this consensus statement).

System-Level Communication—Foundational Principles

3a. We suggest HC/RHAs should have secure online and/or published directories for all partners' clinical and administrative leadership, with emergency contact information (phone numbers, e-mail addresses, pagers, cell phone texting preferences, other means) and current call schedules.

3b. We suggest HC/RHA's should have defined communication vehicles which may include (but are not limited to): dedicated secure health-care coalition web sites; conference call lines and teleconferencing technologies (eg, Skype, others); hospital phones (land lines and cell phones); pagers, hand-held walkie-talkies, ham radios, or other similar means of communication; telemedicine technologies, such as E-ICU, integrated into their disaster plans.

3c. We suggest HC/RHA partners should attempt to routinely use those agreed upon communication vehicles when working together.

3d. We suggest all agreed upon communication vehicles should be tested on a scheduled basis, with objective criteria to validate the test.

3e. We suggest the choice of communication vehicles and testing may be based on likely disaster/pandemic events (Hazard Vulnerability Analyses), and/or other appropriate considerations.

3f. We suggest developing defined disaster/pandemic plans for monitoring and leveraging popular social media (eg, Twitter, Facebook, others) during all actual or potential surge events, or unusual or large scale planned or unplanned events requiring cooperation, as both a means for gathering and transmitting information, as appropriate.

3g. We suggest HC/RHAs should have defined communication tools designated for each level of

organizational leadership, which should be consistent with ICS structure or equivalent.

HC/RHAs are the most important source of accurate, real-time data, with hospitals being the primary interface with patients, the community, and government agencies.^{1,4} They are the information clearinghouses on locations and levels of supplies, medications, beds, personnel, and virtually all resources necessary to coordinate an effective mass critical care disaster response and interface with the media and public (Fig 2).^{1,4,26,27}

Limited information describes how HC/RHA communication systems might function,^{26,27} but we suggest on the use of uniform shared communication systems of varying sophistication. Regardless of which communication modalities are selected, redundancy is important, and back-up systems should always be tested and readily available. Emergency contact information should be easily and quickly accessible, with multiple ways of finding personnel. Web-based or network-centric computer information systems are powerful options, given the volume of information encountered in any disaster and the urgent need to access and assimilate it by partners and government at all levels.^{3,28,29} Additionally, telemedicine technology may be used to improve situational awareness, assist in field triage, and augment local medical surge capacity by providing specialty expertise immediately to the scene of an event.³⁰

Partners should test technologies and processes to verify that they function as planned. We suggest this be done yearly at minimum but strongly encourage partners to use them at every opportunity, from planned large-scale

events and moderate surge events to disasters. Although research on emergency network communication is proposed, no defined standards exist.³¹ Individually developed metrics should focus on the choice of communication vehicles and their accessibility within appropriate time frames under disaster-like circumstances.

Social media, such as Facebook and Twitter, are a powerful way to disseminate information at a stunningly rapid pace during disasters.³² This technology is an important new communication tool, and we suggest HC/RHAs consult with social media experts or software companies in developing strategies to use them.

System-Level Surge Capacity and Capability

4a. We suggest HC/RHA surge objectives should be consistent with individual hospital surge goals and include the capability to surge to:

- Up to 200% above routine maximal capacity based on the nature and severity of the disaster (contingency to crisis)
- Up to the limit of the total number of ventilators available to coalition partners.
- Up to projected patient loads in a slow onset, slow evolving disaster.

4b. We suggest HC/RHAs should be able to monitor and track their defined surge capacity supplies and equipment, ideally “real time” and electronically, with the intent of being able to use all HC/RHA assets. These supplies and equipment may include identified caches of important medications or equipment, and bed availability among partners.

4c. We suggest HC/RHAs should have the ability to track the number of available ICU capable personnel (“force multipliers”) and other designated specialist “resources” (eg, pediatric and special populations) through their partner hospitals. Partners with telemedicine capability (such as tele-ICU’s) should have plans for how to use this resource to optimize the use of pediatric and specialty expertise across hospitals served by the telemedicine resource.

4d. We suggest HC/RHAs should have defined policies and procedures for emergency privileging for all health-care professionals designated as coalition resources.

4e. We suggest fair and adequate reimbursement for expenditures and loss of revenue related to delivery of acute critical care services during a disaster or

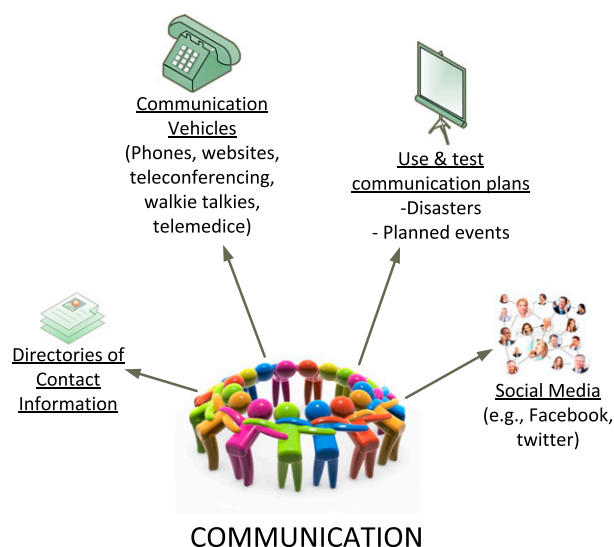


Figure 2 – Summary of suggestions for health-care coalition/regional health authority leadership regarding communication.

pandemic must be ensured. This should include the guarantee of payments from governmental sources, as well as by insurance companies and other payers of health-care services.

In responding to any disaster or pandemic, the task force strongly believes HC/RHAs will be most prepared if they have quantitative knowledge of where resources are available to facilitate access, mobilization, and effective use (Fig 3). These resources include beds, equipment, supplies, and personnel. Suggested system-level surge goals are the same as for individual hospitals and range from conventional (20% above capacity) to contingency (up to 100% above capacity), to crisis surge levels (up to 200% above capacity) (see “Surge Capacity Principles” and “Surge Capacity Logistics” articles by Hick et al²³ and Einav et al,²⁴ respectively, in this consensus statement).³³ Most hospitals and regions have limited reserve bed capacity under routine circumstances, with only 25% maximum number of open beds, which equates to 500 beds per million population.³⁴⁻³⁶ Pediatric beds are scarcer, or may be geographically or otherwise unavailable, with altered standards of care likely needed to accommodate even a moderate disaster surge.^{10,36-38}

Given these considerations, the task force strongly believed it important for HC/RHA leadership to have knowledge of all partner hospitals’ actual and potential bed availability, to be considered as surge capacity. This engagement should occur at the earliest opportunity, especially if there are, or are likely to be, a high number of resource-intense pediatric or specialty care casualties (eg, burns, and so forth) to provide extensive resources quickly, redirect transfers, and provide for the greatest possible breadth of care.

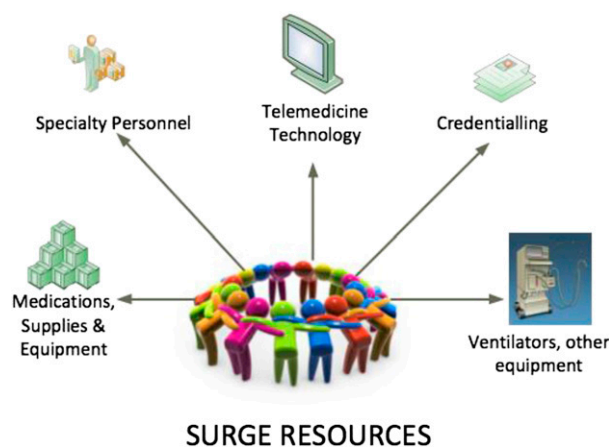


Figure 3 – Summary of suggestions for health-care coalition/regional health authority leadership regarding the number and location of surge resources, and important surge priorities.

In planning transfer of critically ill patients, ED-housed patients may be at less risk than those already admitted, but at increasing risk the longer they reside in an ED.^{39,40} Patients with high acuity, such as those who are mechanically ventilated, may benefit from transfers to tertiary care centers, but specific ICU type (eg, medical ICU, cardiac care unit) is less likely to impact care.⁴¹⁻⁴³ Coordination of patient transfer to facilities with preidentified centers of excellence in critical care is an opportunity to improve patient outcomes further.^{44,45} Critically ill patients not (immediately) triaged to critical care, typically based on various exclusion criteria (see “Triage” article by Christian et al⁴⁶ in this consensus statement⁴⁶), are at increased risk of death.⁴⁷

Surge capacity is limited by the need for one ventilator per mass critical care patient. A recent inventory determined that US hospitals own a supply of 62,188 full-feature ventilators and 98,738 less-advanced ventilators (total, 160,926)⁴⁸ to serve 93,955 ICU beds.⁴⁹ Thus, insufficient ventilators are available to even double usual ICU capability in a national public health emergency without access to regional or national stockpiles. Despite the limitation in ventilator supply and the high occupancy of existing ICU beds, only 29% of average US hospital ICU beds are occupied with a patient on a ventilator.⁵⁰ Other systems, such as county (state-run) hospitals in the United States, Canada, and Europe, routinely run at near 100% capacity with ventilated patients. Thus, the ability of existing critical care services to accommodate substantial mass critical care surges varies widely and can only be established by knowing ventilator capacity and their location.

We suggest mass critical care local operational planning include an inventory of the number of ventilators, including full-feature ventilators, specialized ventilators for newborns, and less-advanced ventilators with limited versatility that nonetheless can be lifesaving in patients with respiratory failure. Suggestions regarding the types and number of medications, critical care supplies, and equipment are found elsewhere in this supplement (see “Surge Capacity Logistics” article by Einav et al²⁴ in this consensus statement).⁵¹ Beds, ventilators, medications, supplies, and equipment should be tracked electronically by HC/RHAs, with knowledge of both their absolute numbers and whereabouts immediately available to system leaders.

Potential critical care surge personnel (force multipliers) should be identified with current contact information (see “Surge Capacity Logistics” article by Einav et al²⁴ in this consensus statement). Given the foreseeable shortage

of intensivists, hospitalists may be the likely group to augment intensive care staffing, although any hospital-based provider may be recruited.^{52,53} Training and just-in-time education for these health-care professionals must be planned so as to provide critical care in an emergency.

Some precedent and support for credentialing health-care professional volunteers in a major disaster exist (See “Legal Preparedness” article by Courtney et al¹³ in this consensus statement).^{54,55} To the degree possible under local law, a mechanism for emergency credentialing of health-care professional volunteers should exist, which may even include HC/RHA partners simply recognizing credentialing processes of other health-care organizations to benefit from each other’s professional pools.

Pediatric Patients and Specialty Populations

5a. We suggest HC/RHA have identified, and be familiar with, the following pediatric disaster/pandemic designated resources including, but not limited to:

- **Pediatric consultative specialists available by dedicated phone line support and/or dedicated video or telemedicine consultation.**
- **Designated pediatric surge personnel (eg, pediatric hospitalists, others) available to non-pediatric hospitals and health systems to support surge in contingency or crisis level events, with a defined plan for how to activate this resource when needed.**
- **Identified pediatric capable transport resources for allocation and matching of pediatric patients to available HC/RHA pediatric resources.**
- **Knowledge of available key supplies, medications, and other pediatric assets; location of these assets with a defined process for how they may be accessed urgently; and ability to monitor when asset reserves fall below a defined critical threshold.**
- **Pediatric educational resources. If web-based, they should be found on HC/RHA websites, or with links to appropriate resources. If published, resources should be readily available to all partners.**

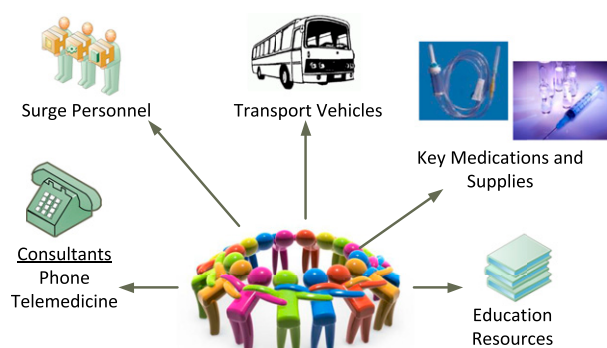
5b. We suggest HC/RHAs should have plans to provide care for specialty populations routinely found in their catchment area or region in parallel as described for pediatrics. Resources should include consultative services, potential surge personnel, transport resources, specialty supplies/medications, and educational resources. These populations include but are not limited to trauma, nephrology, burns, oncologic patients.

5c. Health-care coalitions, health systems, and hospitals identify patients with high-level chronic disease care needs, such as a home ventilator, home oxygen, chronic dialysis, and work to ensure their needs are met at home to help prevent these patients from having to seek assistance at hospitals.

Pediatric hospitals provide superior care for severe pediatric trauma,^{56,57} as well as for critically ill children⁵⁸⁻⁶⁰ and neonates,^{61,62} with better outcomes than nonpediatric facilities. Most children (> 90%) are cared for in nonpediatric EDs, and one-half of these departments see < 10 children each day.⁶³ Fewer than 20% of hospital beds are intended for the care of children, and these are clustered at a minority of hospitals.³⁶ Pediatric critical care beds account for < 10% of all ICU beds in the United States and are clustered at an even smaller number of hospitals.^{49,64} As a result, professional organizations have long recommended that pediatric emergency and critical care resources be regionalized so that resuscitation and stabilization are available close to every community; common low-risk conditions are treated at community hospitals, and high-risk complex conditions are transferred to pediatric hospitals.⁶⁵

Children account for 25% of the population in the United States. It is plausible that in public health emergencies, pediatric surges will exceed age-specific resources even if pediatric patients are proportional to their numbers in the general population. The Pediatric Emergency Mass Critical Care Task Force⁶⁶ recently endorsed CHEST’s mass critical care framework,⁶⁷ and we continue to recommend that pediatric-specific disaster planning is essential. However, to accommodate surges of children, pediatric disaster/pandemic services must be well integrated into regional systems of care.⁶⁶⁻⁶⁸ In a disaster or pandemic, pediatric care is usual care, not specialty care. All HC/RHAs must be prepared to provide care for large numbers of pediatric patients across their region, and operational plans must account for unique local circumstances (Fig 4).¹⁰ Pediatric consultants should be available to all regional partners by phone or telemedicine for remote consultation. Potential benefits of telemedicine communications include improved situational awareness, assistance in field triage, and timely expert consultation.³⁰ Telemedicine communications may be vulnerable to damage in some disasters.⁶⁹

Nonpediatric hospitals must survey and identify staff with pediatric capability, organize contact information, and develop job assignments for them. All members of the hospital team who will provide care to children will



PEDIATRIC SURGE RESOURCES

(Model may also be employed for Special Population Surge Resources)

Figure 4 – Summary of suggestions for health-care coalition/regional health authority leadership regarding pediatric resources (which may also be used for special populations).

benefit from drills and education as well as from just-in-time education tailored to the circumstances of the emergency. Internet resources may be invaluable to support just-in-time education, but electronic access may be unreliable during emergencies, so consideration should be given for printed educational resources.

Interhospital transport resources may also be limited in pandemics and disasters. Decision makers must evaluate the merits of sending critical care staff, supplies, and equipment from uninvolved remote sites to a localized disaster vs transporting the patients from nonpediatric hospitals to a pediatric center. Priorities must be determined for those who should be transferred first (one-on-one transport staffing for the most severely ill patients may exhaust limited critical care resources). In a disaster or pandemic, optimizing population outcomes may require transport strategies distinct from those used in ordinary circumstances, adapting to event-specific local needs and resources (see “Evacuation of the ICU” article by King et al²⁵ in this consensus statement).

Supplies and medications unique to pediatric populations may rapidly be depleted in a large disaster, and the regions’ hospitals should have knowledge and access to these resources at other sites. The levels of supplies should ideally be monitored, as described in the surge article (see “Surge Capacity Logistics” article by Einav et al²⁴ in this consensus statement).

New pediatric-specific evidence may illustrate approaches that also pertain to integrating care of other vulnerable populations into regional systems. HC/RHAs should define their local vulnerable populations, optimally with plans to meet their needs at home rather than in a hospital (see “Special Populations” article by

Dries et al⁷⁰ in this consensus statement). The task force suggests that planning for these vulnerable populations should also mirror the approach described above for pediatric patients.

HC/RHAs and Networks

6a. We suggest during a disaster requiring transfer of patients, whether from emergency medicine departments or inpatient areas, transferring partners may have initial choice of where patients are referred based on traditional referral patterns. However, HC/RHA leadership must oversee this process, and be able to intercede as both a resource and with the authority to redirect transfers based on anticipated or actual events. Defined health-care coalition coordination processes and transfer resources should be planned and identified ahead of time.

6b. Health-care coalitions should designate neighboring health-care coalitions as potential partners during a contingency or crisis event, and have readily available leadership contact information, and knowledge of these potential partners’ size and capabilities.

Hospitals commonly transfer and receive patients along an informal yet structured network based on availability of services, with more-resourced hospitals tending to receive more referrals.^{44,45} Approximately 4.5% of Medicare patients admitted to an ICU ultimately undergo an interhospital critical care transfer.⁴⁵ If a major referral hospital was incapacitated, accepting transfers would halt, and transfer of its own patients would likely be devastating to usual referral networks.⁴⁵ During a major disaster or pandemic, HC/RHA leadership needs to access knowledge of all regional ICU and hospital beds quickly, as discussed previously.

The movement of patients, whether to evacuate a hospital or to decompress a facility to increase acute care capacity, will be enhanced by a regionalized, coordinated, and accountable emergency care system.^{19,71} Neighboring HC/RHA partners are also crucial allies for accepting potential patient transfers; hence, the task force has suggested that all HC/RHAs be familiar with their neighboring coalitions’ leadership, capacity, and organizational capabilities.

Models of Advanced Regional Care Systems

7. Advanced Regional Care Systems instituted within large hospitals, and across hospitals, health systems and HC/RHAs, will have the greatest chance for

success if they are established with the following goals:

- Clear and transparent objectives for what those programs are to accomplish, and the programs are well integrated and accepted across their hospital and health system partners.
- Have administrative and financial resources sufficient to support the objectives desired
- Are evaluated based on objective outcome measures and best-practice process indicators, and strive for consistent data definitions and goals, which facilitate outcome comparison with other systems.
- Are driven by an impassioned performance improvement culture.
- Have effective communication systems and processes across their hospitals, health systems, and HC/RHA partners, between potential pre- and post- hospital partners, and with patients and families.
- Develop clear expectations and supportive clinical and educational resources for patients and their families, especially those patients with chronic medical illnesses.

Advanced regional care systems may be defined as large clinical programs that function across hospitals, health systems, and/or regions and are characterized by established program objectives and performance expectations (Fig 5, e-Table 1). Successful examples include trauma systems, recognized as the standard for best care to injured patients⁷²; telemedicine ICU programs, now numbering > 300 programs in the United States and providing high-quality ICU care for up to 8% of nongovernment ICU beds⁷³; and the Renal Disaster Relief Task Force, with a proven history of

providing urgent dialysis to disaster victims (usually after earthquakes) in less-developed countries^{74,75} (see e-Appendix 1 for further discussion of these examples).

Successful foundations of these programs may be viewed as a five-level pyramid (Fig 5), with the foundation being strong leadership in establishing and planning the vision of the program and securing the necessary financial and political resources.^{17,20,74-77} Successive levels include the culture that drives the clinical systems of care; the clinical data and outcomes used for quality assessment and continuous improvement; and, finally, technology, which is driven primarily by program objectives.^{30,76,78} Quality of patient care is at the top of the pyramid, with mortality data currently the best objective care measure (e-Table 1), with functional outcomes as a high priority, and with patient and family experience being increasingly important.^{72,75,79-84} (Please see e-Appendix 1 for further discussion of advanced regional care systems in relation to trauma networks, telemedicine ICU programs, and the Renal Disaster Relief Task Force.)

The Use of Simulation for Preparedness and Planning

8. We suggest hospitals, health systems, and HC/RHAs promote the use of computer modeling to gain insight into their operational capabilities and limitations, in the following ways:

- Support the creation of computer models utilizing industry templates in collaboration with their own administrative, clinical, and technical resource experts from participating system partners. Models should include government and military resources when applicable, and include provision of maintenance of chronically ill patient populations.
- Collaborate with modelers in the design, implementation, and testing of these models; and with the interpretation and application of these results.
- Support the data requirements for such system models, and develop repositories for operationally relevant data that can be used in future modeling efforts.
- Leverage their relationships with national, regional, and local governments and public health agencies and emergency medical service providers to obtain necessary data on the transportation and patient logistic components of such models as required.

Computer-based modeling is a widely used and powerful tool that helps complex organizations understand their own processes, resources, and capacity in the face of variability in demand and/or supply of services and

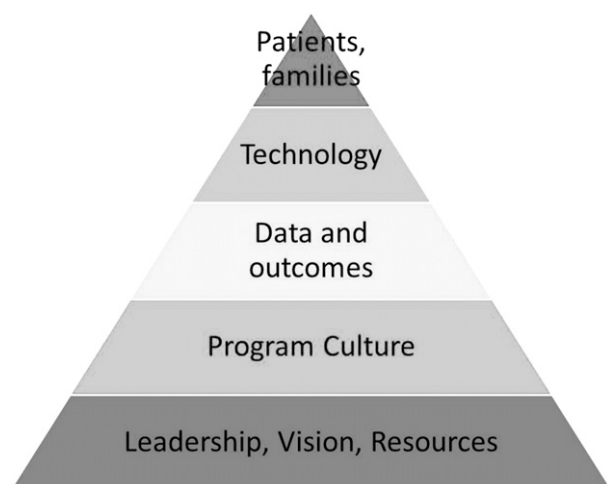


Figure 5 – Pyramid illustrating levels of priorities for successful advanced regional care systems.

matériel.⁸⁵ Mathematical and simulation models have been used to optimize well-defined processes, such as the allocation and movement of prehospital transportation resources,⁸⁶⁻⁸⁸ forecast bed demand and critical resources given normal and exceptional use patterns,^{89,90} and represent health-care resources from the individual facility⁹¹ to a national scale.⁹² Health-system models may use a variety of methods, ranging from queuing theory,⁹³ linear programming,⁸⁶ and spreadsheet modeling⁹⁴ to a variety of computational techniques including Monte Carlo,⁹¹ discrete-event,⁸⁹ and agent-based simulation.⁹⁵

Computer modeling provides benefits for health-system planning and integration. First, efforts to create in silico models of current or planned systems require preliminary interactions among key participants to define capabilities and requirements.⁹⁶ Quantifying current use and resource requirements may help in preparation for surge requirements during disasters/pandemics and provide the rationale for future collaboration and resource-sharing arrangements. Once calibrated, models may be used to explore an evidence-based, system-wide approach to health-system planning and response at both the prehospital and hospital-based levels without causing disruption to current activities.^{87,88}

While “off-the-shelf” modeling platforms are available, the following two-step approach for developing simulations is suggested: (1) Health-care leaders should first specify the operational questions to be answered. For example, Levi and colleagues⁹² (see later) created their model to answer the question of whether bed number was a good marker for operative capability. (2) Once the scope and purpose are clear, health-care leaders may consider reaching out to regional engineering schools, which typically have experience in developing policy-relevant and technically sophisticated simulation with models of complex real-world processes.

An example illustrating both the potential benefits and limits of using modeling for planning mass casualty care is the pioneering study of Levi et al,⁹² in which they developed a novel simulation model of Israeli trauma management to assess how well hospitals’ stated bed capacity correlates with projected operative capability under high-volume scenarios. This exercise required extensive data collection, including historical review of injury number and type (eg, orthopedic, neurologic) and also extensive and detailed information about actual hospital size, bed number, staffing (anesthesiologists and surgeons), and use across the country. Two strategies for load reduction at major trauma centers were tested:

alternating day admissions and triage of less severe cases to outlying hospitals. The unexpected finding was that uniform policies did not always lead to improvement in operative capability and that the gains that did occur were not always proportional to hospital size during the emergency scenario. The health-system-level insights gained through this modeling exercise would have been difficult to ascertain otherwise except in the setting of an actual national disaster. Additionally, access to high-quality, realistic hospital-level data helped create this policy-relevant model.

Conclusions

The Task Force provides an enhanced framework for HC/RHA leaders to optimize teamwork and effective planning in pandemics and disasters. We suggest focusing on including joint communication tools and processes; identification and sharing surge resources, including location, quantity, and how to access them quickly; planning for pediatric populations as usual (not special) care; and understanding internal transfer networks to optimize potential transfers both within their region and to neighboring HC/RHAs. Task force members strongly believe that critical care specialists should be represented in HC/RHA leadership and be actively involved in all disaster/pandemic planning for large numbers of potential critically ill patients. The Task Force also promotes modeling of advanced regional care systems and simulation to provide insight into the development of future processes.

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